Evaluation of Car Performances Using Data Envelopment Analysis

Yunus GÜRAL[1,*] *and Ayşe Turan BUĞATEKİN*[1]

[1]Department of Statistics, University of Fırat, Elazığ, Turkey

Abstract. Data Envelopment Analysis (DEA) is a nonparametric method used to examine the relative efficiencies of Decision Making Units (DMUs) on conditions where there are multiple inputs and multiple outputs. As in all sectors, it is very important for the automotive sector to operate effectively. Therefore, it is also important to measure the efficiency and find the source of the inefficiency. In this study, the performances of the DMU of the automobiles will examine using Data Envelopment Analysis. In this direction, it is aimed to assist consumers in purchasing by calculating the relative efficiencies of automobile models, determining effective and ineffective DMUs according to the wishes of the consumers. Sales price and fuel consumption are determined as input variables; maximum speed, cylinder volume, horsepower, maximum torque, luggage volume, acceleration time from 0 to 100 km are determined as output variables.

1 Introduction

In the automotive sector many brands and models are sold to consumers. The features of the automobile are different in these models. In addition to the features of the automobile price, fuel consumption, comfort and safety are also influential in making decisions for the consumers. These criteria have a great influence on consumers' choice.

DEA was first introduced in 1957 by Farrell in the literature and in the following years different researchers tried to be developed. In 1978 Charnes, Cooper and Rhodes studied it in detail [2].

The DMUs should be similar, since measurements are made relatively in the Data Envelopment Analysis. DEA is a method that uses similar inputs to obtain similar outputs.

In this study, the most selling car models in Turkey in 2017 are included. According to the wishes of the consumers it is aimed to assist consumers in purchasing by calculating the relative efficiencies of automobile models and determining effective and ineffective DMUs.

* Corresponding author: ygural@firat.edu.tr

2 Data Envelopment Analysis

DEA is a linear programming technique for measuring the relative efficiency of DMUs with multiple inputs and multiple number of outputs. DEA is used in many areas such as Health, Sports, Finance, Tourism, Marketing, Education [1,3]. The advantage of the DEA over other non-parametric methods is that multiple outputs can be measured in the production process. DEA identifies effective and ineffective DMUs. It also provides information on the amount and the source of ineffectiveness of DMUs.

2.1 Implementation Objectives of DEA

- Determine the amount and source of inefficiency of ineffective units,
- Creation of a reference set,
- Improving resources by reference set,
- Evaluation of the appropriateness of the administrations.

2.2 Charnes, Cooper, Rhodes (CCR)

CCR is the basic DEA model developed by Charnes, Cooper, Rhodes. Input-oriented CCR is concerned with how much input will be reduced to achieve the desired output. The output-oriented CCR is concerned with how much output level will increased by the amount of input available.

2.2.1 Output-oriented CCR (CCR-O)

CCR-O is the model that calculates how much increase the amount of output without changing the input level. Output-oriented CCR model [3] as follows

$$Max\beta_k + \varepsilon \sum_{r=1}^{l} T_r^- + \varepsilon \sum_{i=1}^{m} T_i^+$$

$$T_r^- + \sum_{j=1}^{t} \lambda_{jk} X_{rj} = X_{rk}$$

$$-T_i^+ + \sum_{j=1}^{t} \lambda_{jk} Y_{ij} - \beta_k Y_{ik} = 0$$

$$\lambda_{jk}, T_r^-, T_i^+ \geq 0$$

If $\beta^* = 1$, DMU is efficient. If $\beta^* > 1$ or slack variables are not zero, then DMU is inefficient.

For the full efficiency of the DMU, $\beta^* = 1$ and all slack variables must be zero. If $\beta^* = 1$ but one of the slack variables is different from zero, it is called weak efficient [4].

For an ineffective DMU to be effective, target values are calculated using the following formula.

$$X_{rk} = X_{rk} - T_r^{-*} \quad ; r = 1, \dots, l \tag{1}$$

$$Y_{ik} = \beta_k^* Y_{ik} + T_i^{+*} ; i = 1, \dots, m \tag{2}$$

Table 1. Efficiency Values of car model.

Segment C Sedan	**Efficiency**	**Segment C HB**	**Efficiency**	**Segment C Suv**	**Efficiency**
Fiat Egea	1	VW Golf	1,01723	Nissan Qashqai	1
Renault Megane	1	Seat Leon	1	Dacia Duster	1
Toyota Corolla	1	Opel Astra 1.6 Cdti Enjoy	1	VW Tiguan	1
Ford Focus	1	Renault Megane	1	Hyundai Tucson	1
Opel Astra	1	Fiat Egea	1,00306	Toyota C-Hr	1
Honda Civic	1,01163	Toyota Auris	1	Peugeot 3008	1
VW Jetta	1	Audi A3 Sportback	1	Renault Kadjar	1
Skoda Octavia	1	Bmw 1 serial 116d	1	Ford Kuga	1
Audi A3	1	Mercedes A Serial A180	1,0192	Honda CR-V	1
Mercedes CLA 180	1,02588	Hyundai İ30	1	Kia Sportage	1
Mazda 3	1,02173	Nissan Pulsar	1	Mercedes GLA 200	1
Mitsubishi Lancer	1,05338	Peugeot 308	1	Seat Ateca	1,022691
		Skoda Rapid Spaceback	1	Bmw X1	1
		Honda Civic	1	Subaru Forester 2	1,048195
		Ford Focus	1	Audi Q3	1
		Volvo V40	1	Subaru XV	1,058605
		Volvo V40 Cross Country	1,0198	Mini Countryman	1,030307
		Citroen C4	1,0521	Range Rover Evoque	1
		Alfa Romeo Giulietta	1	Skoda Yeti	1
		Kia Cee'd	1	Mitsubishi ASX	1,026402
				Toyota RAV4	1
				Mazda CX-5	1

Table 2. Efficiency Values of car model.

Segment B	**Efficiency**	**Segment D**	**Efficiency**
Toyota Yaris	1	VW Passat	1
VW Polo	1	Mercedes C180	1
Honda Jazz	1	Skoda Superb	1
Kia Rio	1,0317	Opel Insignia	1
Ford Fiesta	1	Audi A4	1,00645
Hyundai i20	1,0254	Bmw 318d	1
Renault Clio	1	Renault Talisman	1
Citroen C3	1	Ford Mondeo	1,02004
Opel Corsa	1,04848	Volvo S60	1
Peugeot 208	1	Peugeot 508	1
Dacia Sandero	1	Toyota Avensis	1
Nissan Micra	1		
Skoda Fabia	1		
Mini Cooper	1		
Audi A1 Sportback	1		
Suzuki Baleno	1,0255		

In Turkey best-selling car models in 2017 were included in the application. According to Table 1 and 2, twenty of these car models are not effective. Target values for ineffective automobile models can be found using (1) and (2).

3 Conclusion

Relative efficiency measurement by Data Envelopment Analysis has many application fields in many sectors such as education, bank and health. However, unlike these sectors, it is noteworthy that in the automotive sector there are very few studies in which the relative efficiencies of automobile models are measured using DEA, especially from a consumer point of view. In addition, DEA based decision support system has been created to help automobile consumers make purchasing decisions. It is believed that this aspect of the work contributes to the literature and thus may be a guide to similar work in the future.

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